

Chapter 4

Management Plan Elements

4.1 Groundwater Management Goal

The management elements of this GMP include the primary goal of adequately addressing Zone 7's Groundwater Basin Management Objectives or BMOs (see Section 1.4): to provide for the control and conservation of waters for beneficial future uses, the conjunctive use of groundwater and surface water, the importation of additional surface water, and the use of the groundwater basin to serve as water storage for drought periods. This is accomplished through a set of Resource Management and Other Planning Efforts (described below) and a group of management plan components that identify the necessary actions for meeting goals and objectives. The purpose of this GMP is to compile and document the existing successful programs and policies for management of groundwater resources and to develop a framework for the implementation of future activities to ensure reliability and quality of regional groundwater.

4.2 Resource Management and Other Planning Efforts

Zone 7's primary groundwater BMOs provide for control and conservation of waters for beneficial future uses, conjunctive use of groundwater and surface water, importation of additional surface water, and use of the groundwater basin to serve as water storage for drought periods. According to the 1987 "Statement on Zone 7 Groundwater Management" located in Appendix E, Zone 7's groundwater management goals include:

- to maintain the balance between the combination of natural and artificial recharge and withdrawal;
- to maintain water levels high enough to provide emergency reserves adequate for the worst credible drought;
- to protect and enhance the quality of the groundwater;
- to develop information, policies and procedures for effective long-term management of the groundwater basin; and

- to inform the public and relevant governmental agencies (including the TVG) and the four individual retailers, DSRSD, CWS, Livermore and Pleasanton) of the Zone’s water supply potential and management policies, and to solicit their input and cooperation.

Examples of current groundwater basin management operations include:

- **Monitoring and maintenance of groundwater levels**—a long-term conjunctive use program at Zone 7. Underneath the Tri-Valley lies a groundwater basin that contains about 250,000 acre-feet of usable groundwater. An acre-foot is about 326,000 gallons, enough water to supply two households for a year. The groundwater basin provides the community with a “water savings account,” which serves as a hedge against a prolonged dry period or a temporary inability to import surface water. In the event of a prolonged drought, this amount of water is enough to sustain the entire Tri-Valley for up to 6 years, depending on the amount of surface water available and the conservation efforts of water users.

Zone 7 accesses the groundwater through wells at aboveground pumping facilities. Zone 7 pumps more groundwater during peak demand periods or in dry years when imported supplies are low. Local water retailers also access the groundwater basin for drinking water.

- **Artificial Recharge Program**—The groundwater basin is naturally refilled, or “recharged,” by streamflow, underground flows, rainfall, and applied irrigation water seeping into the ground. Zone 7’s groundwater management program ensures that water levels in the basin will remain at or above acceptable levels.

In addition to natural recharge, Zone 7 manages an artificial recharge program. During spring, summer, and fall when the streams are typically dry, Zone 7 releases some of its purchased imported water into the Arroyo Valle and Arroyo Mocho. By allowing the water to flow through sections of these arroyos where the creek bottoms are very porous, the water quickly seeps into the ground, replenishing the groundwater basin. By artificially refilling or recharging the groundwater basin, and monitoring water levels throughout the valley, Zone 7 ensures that the water demands of the community are met.

Specific objectives include managing the groundwater basin to:

- ❑ maintain “emergency reserve” by keeping water levels above historical lows,
 - ❑ allow for gravel mining,
 - ❑ prevent overdraft from pumping (maintain total pumping at or below sustainable/safe yields), and
 - ❑ reserve storage for drought events.
- **Groundwater quality**—monitoring and management, as well as protection against any degradation:
 - ❑ mitigate degradation from salt buildup;

- ❑ minimize flow of poor quality shallow groundwater into deep aquifers;
- ❑ offset impacts of water recycling and wastewater disposal through integrated SMP;
- ❑ recharge with low TDS/hardness water;
- ❑ manage quality on a regional basis as measured at municipal wells, thus allowing localized degradation as long as the overall basin is protected
- ❑ minimize threats of groundwater pollution through groundwater protection;
- ❑ monitor and prevent inelastic land surface subsidence; and
- ❑ monitor changes in surface flow and surface quality, especially as they affect groundwater levels or quality or are caused by groundwater pumping in the basin.

4.3 Stakeholder Involvement

4.3.1 Involving the Public

A key purpose of this Groundwater Management Plan is to compile and document existing groundwater management plans and policies. One of the more recent contributions to this groundwater management toolbox is the development of the Salt Management Plan (SMP).

The SMP, incorporated herein by reference (a copy of the executive summary is included in Appendix D), was prepared in fulfillment of Master Water Recycling Permit Order No. 93-159 Provision D.1.c.ii and General Water Recycling Permit Order No. 96-011 Provision D.4. This document not only provides a comprehensive and effective approach for administering, regulating and encouraging water recycling in the Livermore-Amador Valley, it also provides guidance to the area's agencies on ways to address the historical trend of increasing TDS in the main groundwater basin. It was developed by Zone 7 staff and consultants in partnership with a TAG composed of local water retailers, and a Zone 7 citizens committee—the GMAC. The RWQCB approved the SMP in October 2004.

As with the formal process utilized in developing the SMP, Zone 7 actively involves the public in all its programs through a variety of meetings, and through media such as the Internet. This approach has been included as an explicit operational policy in Zone 7's 1987 Statement on Groundwater Management (again incorporated herein by reference; a copy is included in Appendix E). Zone 7 holds monthly Board meetings that are open to the public and conducts frequent meetings with its water retailers. The public can also access the Zone 7 website for general information or download reports on a variety of topics. In addition, the public can get involved with Zone 7 planning and management through the RWQCB Basin Planning process. The Zone 7 website can be accessed at <<http://www.zone7water.com>>.

Examples of the different types of public involvement in Zone 7's groundwater management programs include:

- retailer contracts (including pumping quotas);
- meetings with retail water agencies (DSRSD, CalWater, Pleasanton and Livermore);
- Memorandum of Understanding (MOU) for well ordinance administration within respective city limits;
- stakeholders meetings (e.g., Alameda Creek Watershed Management Program);
- data-sharing with retailers, public and other agencies (RWQCB, DHS, and County Environmental Health);
- reports at public board meetings (three formal presentations to Board and public in 2004 on groundwater basin management);
- website postings, including annual reports, quarterly groundwater reports and water awareness fact sheets;
- kiosk stations (watershed, groundwater basin and artificial stream recharge information along footpaths that border key recharging streams), county fair booths, Earth Day events, etc.;
- press releases, Water Ways newsletter;
- Groundwater Management Advisory Committee or GMAC—10-member citizens committee formed 1995–2002 primarily in relation to the demonstration RO/groundwater injection project; however also assisted in the major review and update of the 1987 GMP, as reflected in the newly created Salt Management Plan or SMP;
- Technical Advisory Committee or TAC (technical staff from the four retail water agencies) formed in 1995–2002 in conjunction with GMAC to assist in the development of the SMP which included major review and update of the 1987 GMP;
- elementary school (K-8) program, using consultants; and
- secondary school science program—cooperative program with Zone 7 staff, LLNL, retailers, Tri-Valley ROP; brings water science and water industry career information into the high schools.

4.4 Development of Relationships with State, Federal, and Local Agencies

Working relationships between Zone 7 and the state, federal, and local agencies are critical to developing and implementing the various groundwater management strategies and actions detailed in this GMP.

Zone 7 has, and will continue to develop, an excellent working relationship with DWR, RWQCB and any relevant federal agency for the necessary means of protecting the beneficial uses of the Livermore-Amador Valley groundwater basin. For example, Zone 7 in conjunction with DWR wrote *Evaluation of the Groundwater Resources: Livermore and Sunol Valleys* in 1974. In addition, Zone 7 plans to continue working with DHS on regulating drinking water and municipal wells; the RWQCB on NPDES and Basin Planning (such as the SMP); Alameda County Environmental Health on issues where groundwater has been affected; DFG and USFWS on recharge program operations; and the Corps on diversion and creek projects.

Over the years, Zone 7 has fostered excellent working relationships with local entities through contracts, policies and resolutions such as those included in Appendix E of this document. In particular, Zone 7 solicits input from the TVRG and its four member agencies, DSRSD, CWS, Pleasanton and Livermore. As with the SMP, any future changes to this Groundwater Management Plan and Zone 7's existing groundwater management policies and procedures would be the result of collaboration with the TVRG and its member agencies.

Zone 7 also maintains relationships with the local water retailers and Planning Agencies (such as the County and the City of Dublin) to ensure that adequate land use planning and protocols are up to date to ensure the beneficial use of the groundwater basin. Zone 7 reviews CEQA documents for all new developments and coordinates with cities and counties to ensure accurate planning.

In addition, Zone 7 is a member of the Tri-Valley Regional Geographic Information Systems User Group (TVRGIS User Group). The TVRGIS was formed to address the electronic sharing of spatial data (e.g., parcel base-maps, centerlines, public trails, drainages, ortho-photography, zoning and general plan land use) and to minimize the overlap in spatial data that each agency uses. The TVRGIS, which includes GIS coordinators from the Town of Danville, City of Dublin, City of Livermore, City of Pleasanton, and Zone 7, addresses the sharing of spatial data for local and regional planning, management, and public safety purposes.

4.5 Monitoring Programs and Protocols

Zone 7 currently monitors the conditions of the groundwater basin. This section of the GMP describes Zone 7's monitoring programs. Standard Operating Procedures (SOPs) can be seen in Appendix C. Table 4-1, below, summarizes details regarding these programs.

Table 4-1. Monitoring Programs and Protocols

Monitoring Type	Location	Measurement Type	Date Started	Frequency	Notes
Climatological Monitoring Program					
Precipitation	9 stations including 8 with storage gages and 5 with recorders	Storage Gage (8) Recorder (5)	Jan 1871	Daily Continuous	Reported in: Climatological Reports (monthly/annually) and Stream Reports (daily/monthly/annually)
Evaporation	Lake Del Valle	Pan Evaporation	October 1969	Daily	Reported in: Climatological Reports
Evapotranspiration	CIMIS Station (Fairgrounds, Pleasanton)	Automated active weather station	June 2004	Daily	Reported in: Climatological Reports
Surface Water Monitoring Program					
Streamflow	47 Stations including 10 recorder stations on three streams: Arroyo Valle Arroyo Mocho Arroyo De Las Positas	Stream Gages Meters Recorders	1912	Daily Daily Continuous	Reports: Annual Stream Recharge Report; Daily Stream Flow Reports; Quarterly Water Supply Report; Monthly Groundwater Supply and Utilization Report
Surface Water Quality	16 stations		1948	Annually	Monitoring performed by Zone 7 beginning in 1974; Stormwater Quality Management Plan and Program, as required by RWQCB Orders R2-2003-0021 and 93-159; reported in SW Annual Report
Recharge	Three streams: Arroyo Valle Arroyo Mocho Arroyo Las Positas	Metered and gaged records	1974	Monthly	DWR calculated various forms of stream, artificial and natural recharge in 1966; currently reported in Monthly Groundwater Supply and Utilization Report
Groundwater Monitoring Program					
Well Inventory	By Township/Range: 2S/1E, 2S/2E, 2S/1W, 3S/1E, 3S/2E, 3S/1W	Data Base and Hard Copies	1973 Historic from 1906	Ongoing	Zone 7 began collecting and maintaining well inventory information in about the mid-1970's; information was initially collected by DWR for regional studies published in 1953, 1955, 1963, 1966 and 1974. Zone 7 obtained all historic well records and since 1973 has obtained all well records through the drilling permit process.

Monitoring Type	Location	Measurement Type	Date Started	Frequency	Notes
Groundwater Levels	Currently 224 wells measured semi-annually; 80 wells measured monthly; 9 wells continuously monitored	Pressure transducers Steel and electrical tapes	1946 Historic from 1900	Recorder, monthly and semiannual	Data collection began with three wells in about the mid-1940's when multi-year drought resulted in groundwater level drops and DWR began taking an interest in the area; Zone 7 has managed the program for the last 30 years, adding other wells to its growing program; reported in Groundwater Level Report (monthly/semi-annual)
Groundwater Quality	Currently 218 wells sampled and analyzed for TDS, major minerals and metals.	Analytical	1946 Historic to 1908	Annually	Focus has been on salt (mineral) concentrations, as represented by TDS levels; subsequently, program expanded to include pollutants and other WQ parameters; reported in Annual Groundwater Report, semiannual Groundwater Quality Summary; Monthly Municipal Groundwater Quality Report
Land Surface Elevation Monitoring Program					
Land Surface Elevations	50 Benchmarks	Surveying	Historic 1912 Elastic seasonal 2002	Periodic and Semiannually	Land Surface Elevation Report
Groundwater Production Monitoring Program					
Pumpage	Major pumping wells (Zone 7, retailers, etc.)	Metered	1974	Monthly	Reported in Water Users Reports; Annual groundwater Supply and Use Forecast Report; Monthly Municipal Water Supply Reports
Other Programs					
Wastewater Export/Disposal			1979	Monthly	Outside Agency Jurisdiction (Managed by DSRSD and City of Livermore; data includes flow, TDS, major minerals & metals)
Recycled Water Production & Use		Metered		Monthly	Outside Agency Jurisdiction (Managed by DSRSD and City of Livermore)

Zone 7's key monitoring programs include (and are described in detail below and on Table 4-1):

- climatological monitoring,
- groundwater elevation and quality monitoring,
- surface water flow and quality monitoring,
- land surface elevation and inelastic subsidence monitoring,
- mining area monitoring,
- land use monitoring,
- groundwater production monitoring, and
- wastewater disposal.

Figure 4-1 shows the entire basin well-monitoring program.

4.5.1 Climatological Monitoring

4.5.1.1 Background/Introduction

Zone 7 actively monitors and compiles climate data from a network of rainfall and evaporation stations throughout the Livermore-Amador Valley watershed. Climatological data are used to calculate specific components of the annual recharge totals, evaporative losses, and evapotranspiration demands.

4.5.1.2 Program Description

The Zone 7 climatological monitoring program network consists of nine rainfall stations and two pan evaporation stations located within the 400-square-mile Livermore Valley watershed (Tables 4-2 and 4-3). The locations of the stations and the lines of equal mean annual rainfall (isohyets) are shown in Figure 4-2. There are three types of precipitation stations in the network:

- Four Daily Record Stations—consist of a storage gage that measures the depth of rain that has fallen during the preceding 24 hours. Three of these stations are operated by private observers.
- Four Recorder Stations—consist of a storage gage (same as those described above) and a computerized tipping bucket recorder that continuously record hourly rainfall. All four stations are operated by Zone 7.
- One California Irrigation Management Information System (CIMIS) Station—installed and operated with assistance from DWR, this station collects/records/calculates data for precipitation, air temperature, soil temperature, wind speed, wind direction, solar radiation and evapotranspiration

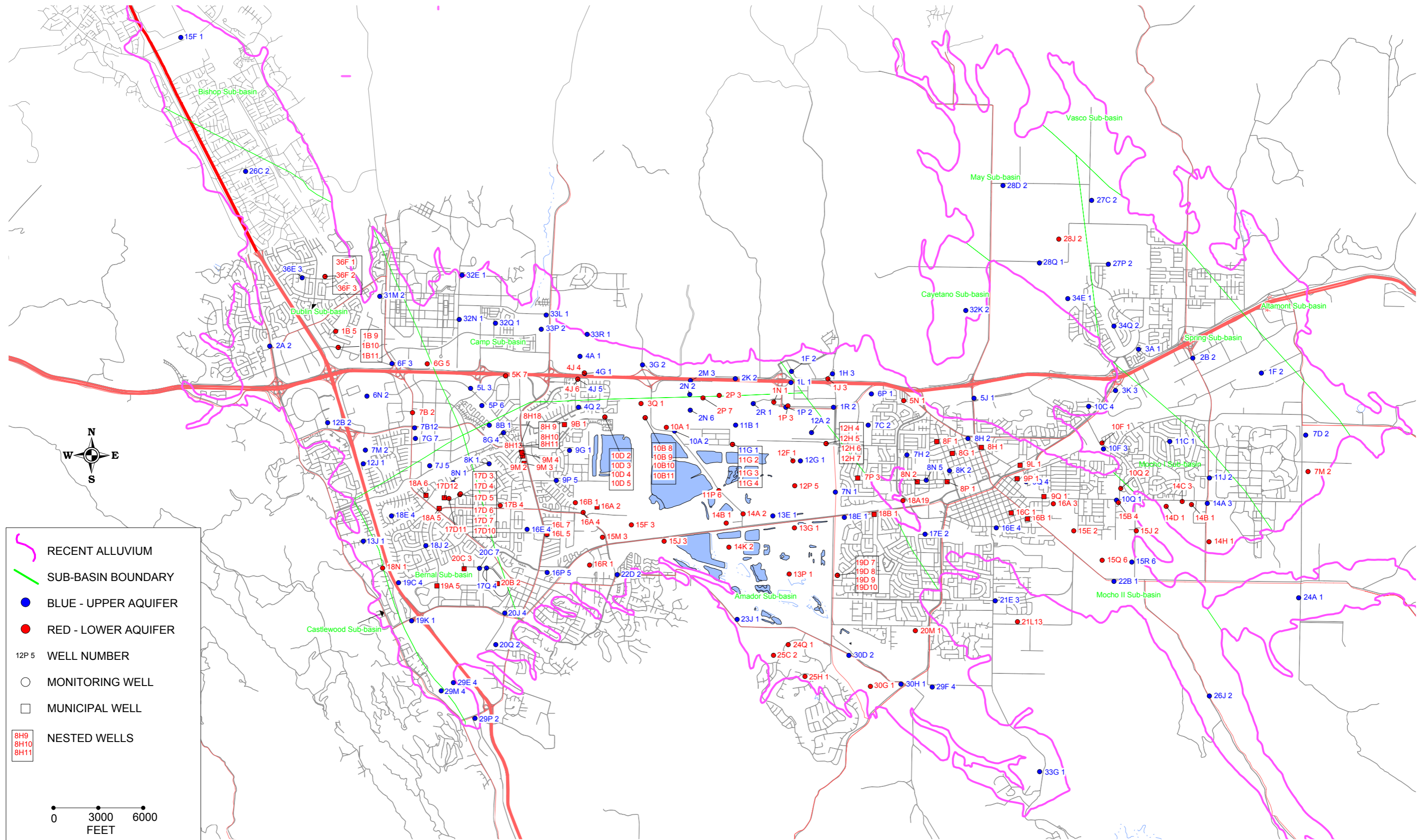
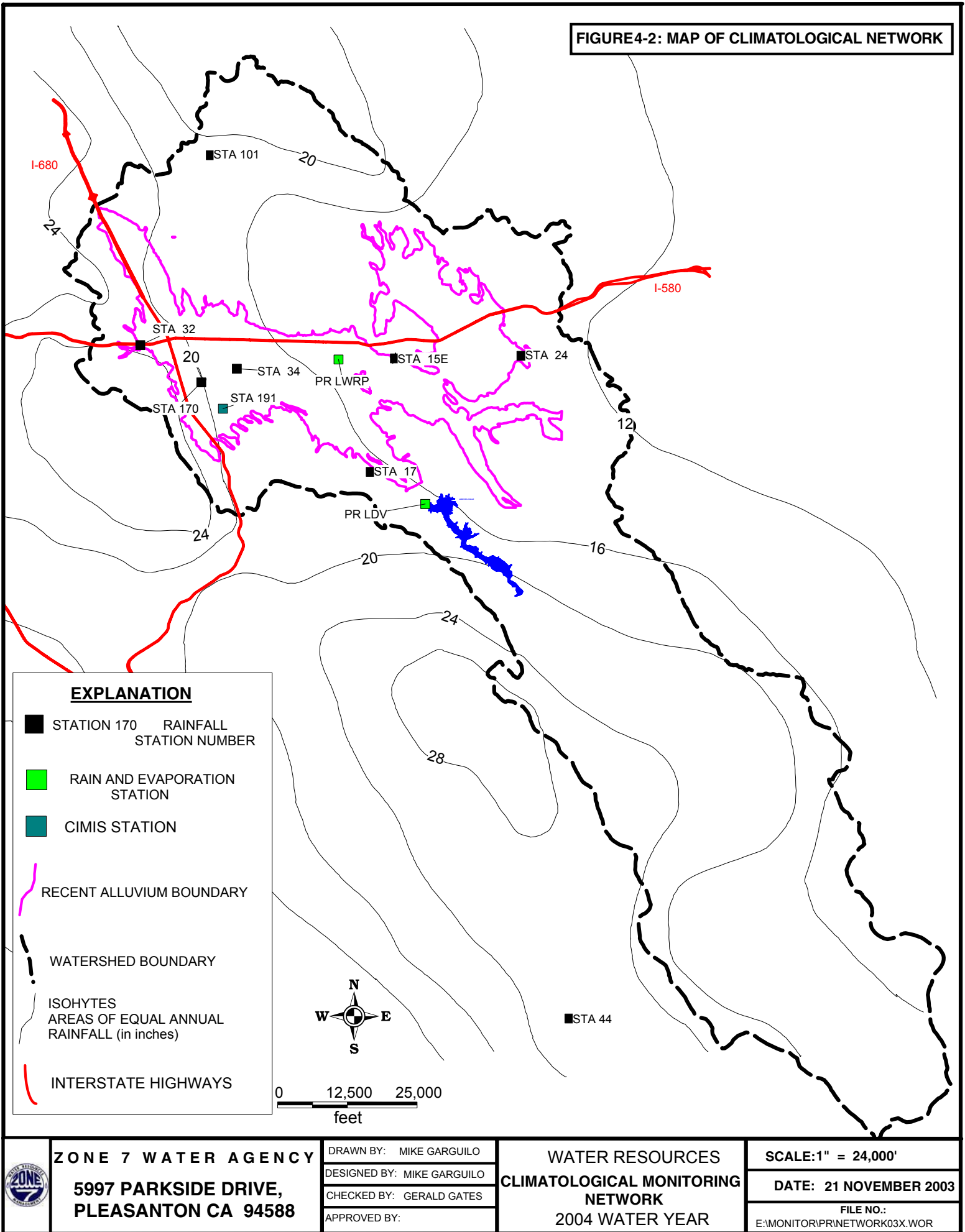


FIGURE 4-2: MAP OF CLIMATOLOGICAL NETWORK



The program also includes two evaporation stations that collect data with an evaporation pan. The Lake Del Valle (LDV) station, operated by DWR is a part of LDV operations. The Livermore Water Reclamation Plant (LWRP) operates the LWRP station as part of their wastewater treatment plant operations.

Table 4-2. Precipitation Network

Station ID	Site ID	Station Name	Location	Observer	Elevation	Station Established		Mean Annual Precipitation Inches
						Storage Gage (Daily)	Recorder Record	
15E	CM_ST A 15E	NOAA Livermore	Wellingham Drive, Livermore CCN: 2077172 CCE: 6194524	Mr. Ron Hafner	480	1871	–	14.60
17	CM_ST A 17	Del Valle Plant	Vallecitos Road, Livermore CCN: 2054906 CCE: 6189667	Zone 7 Staff	640	1974	1978	16.26
24	CM_ST A 24	Patterson Plant	Patterson Pass Road, Livermore CCN: 2077605 CCE: 6219168	Zone 7 Staff	680	1963	1969	13.09
32	CM_ST A 32	Dublin Canyon	Dublin Canyon Road, Pleasanton CCN: 2079706 CCE: 6144577	Mr. H.W. Kolb	450	1937	–	23.27
34 and 34TB	CM_ST A 34	Mocho Well Field	Santa Rita Road, Pleasanton CCN: 2075106 CCE: 6163467	Zone 7 Staff	340	1968	1970	17.88
44	CM_ST A 44	Mt Hamilton	Lick Observatory, Mt Hamilton CCN: 1947881 CCE: 6228576	Lick Observatory Staff	4209	1881	–	24.63
101	CM_ST A 101	Tassajara	Camino Tassajara Road, Danville CCN: 2116905 CCE: 6158368	Mrs. Joan Hansen	800	1912	–	18.34
170	CM_ST A 170	Zone 7 Office - old	Parkside Drive, Pleasanton CCN: 2072426 CCE: 6156517	Zone 7 Staff	330	1986	1986	20.63

Station ID	Site ID	Station Name	Location	Observer	Elevation	Station Established		Mean Annual Precipitation Inches
						Storage Gage (Daily)	Recorder Record	
191	CM_ST A 191	CIMIS Station	Alameda County Fairgrounds, Pleasanton CCN: 2067061 CCE: 6161028	DWR and Zone 7 Staff	335	–	2004	19.39

Table 4-3. Evaporation Network

Station ID	Site ID	Station Name	Location	Observer	Elevation	Station Established	Mean Annual Evaporation Inches
LDV	CM_EV_LDV	Lake Del Valle	Arroyo Road, Livermore CCN: 2048605 CCE: 6200367	DWR Staff	760	1969	65.84
LWRP	CM_EV_LWRP	Livermore Water Reclamation Plant	Kitty Hawk Road, Livermore CCN: 2076905 CCE: 6183367	LWRP Staff	405	1967	73.01

4.5.1.3 Reporting

Throughout the water year several reports are generated to display, review, and discuss the data that was gathered:

- Climatological Data Monthly Report,
- Climatological Monitoring Annual Report, and
- Climatological Monitoring Program Design Report—Annual Program Update.

The results of this monitoring program are used for operational decisions, monitoring decisions, and in recharge calculations (Section 4.6.2).

4.5.2 Groundwater Elevation and Quality Monitoring

4.5.2.1 Background/Introduction

Since the early 1900s there has been a long history of groundwater use, level measurements, and water quality testing in the Livermore-Amador Valley. Zone 7 has compiled a historical database of available water level and quality

data pertaining to the groundwater basin. Zone 7's historical database contains records compiled from many sources consisting of major mineral water quality data from 1,122 wells and groundwater level data from 2,319 wells.

Zone 7's groundwater monitoring program includes the monitoring of:

- groundwater elevations to determine the volume and movement of groundwater within the basin, and
- groundwater quality to determine the status of current water quality and long-term trends.

4.5.2.2 Program Description

Zone 7 monitors approximately 225 wells in the Main Basin. Groundwater wells in this program are defined as one of the following types:

- monitoring—used only for monitoring (i.e., no groundwater extraction), including at least 11 nested well sets for monitoring specific water bearing units;
- municipal—municipal water supply well owned by Zone 7, San Francisco Water District, City of Pleasanton, or Cal Water Service;
- potable—drinking water supply well for residences (potable domestic) or non-municipal public supply (potable public); or
- agriculture—extraction well for agriculture use.

Zone 7's Groundwater Monitoring Program includes monitoring for the following reasons:

- **Monthly basin levels**—includes a network of wells that are monitored, reported, and reviewed monthly for groundwater levels. These data are used for ongoing studies of subsurface inflow, identification and confirmation of hydrostratigraphic units, monitoring of groundwater extraction by others, tracking pumping and static water levels, and determining pumping costs.
- **Groundwater basin seasonal extremes**—to determine basin-wide water levels at the two extremes of the annual cycle.
- **Groundwater basin quality**—to track water quality in the groundwater basin and migration patterns of minerals and metals towards pumping wells.
- **Geologic Evaluation**—to identify geologic conditions of the basin and surrounding areas. This evaluation is performed constantly and includes compiling historic geologic maps by others, evaluation of drilling logs and logs, identifying water level and quality trends, and making outcrop field visits.
- **Water rights**—The conditions of this permit require that Zone 7 conduct a groundwater investigation that includes sampling of four groundwater wells along the Arroyo Valle semi-annually, measuring water levels from a

specific set of wells collected monthly, and collecting water level recorder measurements from two wells.

- **DWR**—in a cooperative agreement with the DWR, Zone 7 takes split groundwater samples from some wells to supply DWR with groundwater quality data and to supply quality assurance/quality control (QA/QC) data for Zone 7 sampling.

All of the wells to be monitored in the program fulfill some of the needs for a basin evaluation or a regulatory objective. Some wells are assigned to multiple purposes depending on the suitability of the well.

The program includes the monthly measurement of groundwater levels in about 80 wells and semiannual measurements in about 224 wells. Approximately 200 wells are sampled annually. These samples are tested in the field for EC, pH, and temperature. The samples are then submitted to the Zone 7 laboratory and are analyzed with various minerals, metals, and other parameters including those seen in Table 4-4.

Table 4-4. Water Quality Monitoring Constituents

Minerals	Metals	Other
Calcium	Boron	Total Dissolved Solids
Magnesium*	Arsenic	Total Hardness
Sodium	Chromium	Electrical Conductivity
Potassium	Manganese	Alkalinity
Bicarbonate*	Selenium	Calcium Hardness
Sulfate	Iron	
Chloride	Lead	
Nitrate	Copper	
Silica	Mercury	
Carbonate*	Others	
* Calculated		

The Monitoring Protocols Table (Table 4-1) identifies the number of wells that are measured for groundwater levels and sampled for groundwater quality and the associated objective.

4.5.2.3 Reporting

Throughout the water year several reports are generated to display, review, analyze, and discuss the data that were gathered both internally and with interested stakeholders:

- **Key Well Report**—submitted to Zone 7 Board quarterly

- Groundwater Level Monitoring Monthly Report
- Quarterly Municipal Groundwater Quality Report
- Semi-Annual Groundwater Level Report
- Groundwater Annual Monitoring Report
- Groundwater Program Design Report—annually

Internal reports are also generated to review the data:

- Groundwater Level Hydrograph Report
- Groundwater Hydrochemograph Report (semiannually)
- Groundwater Quality Summary Report (semiannually)

The results of this program are used for groundwater storage calculations, supply and demand inventory, recharge calculations, salt management, and groundwater modeling.

4.5.3 Surface Water Flow and Quality Monitoring

4.5.3.1 Background/Introduction

Surface water in the Livermore-Amador Valley consists of:

- watershed runoff into Lake Del Valle;
- local natural runoff into four major streams (Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Arroyo de la Laguna);
- rainfall and urban runoff;
- water from several quarry ponds (mining area);
- applied irrigation water seepage and runoff; and
- imported water conveyed in the SBA and released into local arroyos.

As part of its Groundwater Management Program, Zone 7 operates a surface water–monitoring program in the valley to measure the quantity and quality of stream water recharging the groundwater basin and to provide sufficiently detailed data to manage the local water supply. The monitoring program focuses on the streams that recharge the groundwater basin (Arroyo Valle, the Arroyo Mocho, the Arroyo Las Positas, and the Arroyo de la Laguna; see Figure 4-3) and the diversions and accretions that affect the flow along them. Zone 7 has compiled water flow data from these streams back to 1912 and water quality data back to 1948.

Zone 7, which is also responsible for streamflow management of controlled releases to various streams, has implemented a surface water monitoring program that includes a network of recorder, meter, and staff gage sites that monitor the

quality and quantity of stream flow 365 days a year. This network characterizes the flow and water quality in all major tributaries of the watershed.

4.5.3.2 Program Description

There are about 120 existing surface water monitoring sites in the Livermore Valley. For its surface water program, Zone 7 monitors 47 of these sites for flow and 16 for quality (see Figure 4-3 and Table 4-1). Sites are classified as:

- inflow/outflow—represents discharge or diversion sites where there is an inflow into or outflow from the stream, or
- monitoring—represents sites where flow and/or water quality monitoring occurs in the stream.

Sites have a measurement device to directly or indirectly record flow and/or water quality. These are listed in Figure 4-3 and Table 4-5 as:

- continuous recorder station—produces a continuous (15-minute) record of stream gage height and/or quality,
- meter—meter that records the volume of water flow,
- staff gage—a graduated tape or pole that measures the stream gage-height,
- calculated—virtual site where flow or quality is calculated,
- none/other—none of the above.

Table 4-5. 2004 Surface Water Program Sites

Site	Location	Type	Device	Objectives					Notes
				Std		Wtr Rts		NP	
				Flw	Qlty	Flw	Qlty	Qlty	
Arroyo De La Laguna—Line B									
HOP9_PC	Hopyard 9 Waste to Pleasanton Canal (ADLL)	Inflow/ Outflow	Meter	D					
ADLLV	Arroyo De La Laguna at Verona	Measurement	Recorder	R	A				Started in 2004. Std Analysis
ADLLP	Arroyo De La Laguna near Pleasanton	Measurement	Recorder	R					Discontinued in 2004
Arroyo Las Positas—Line H									
ALP_APPWTP	Arroyo Las Positas above PPWTP	Measurement	None					A	Dry in 2004
PPWTP_DISCH	PPWTP Discharge to Arroyo Las Positas	Inflow/ Outflow	Meter	D					
ALP_BPPWTP	Arroyo Las Positas Below PPWTP	Measurement	None					A	Dry in 2004



ZONE 7 WATER AGENCY
100 NORTH CANYONS PKWY, LIVERMORE CA 94551

DRAWN BY: MG/TR
DESIGNED BY: MIKE GARGUILO
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Figs\\Tabls\\Fig4-2004SWStations.WOR

**Locations of Sites in
2004 Surface Water Program**

SCALE: 1" = 1 MILE
DATE: Apr 7, 2005
FIGURE 4-3

Site	Location	Type	Device	Objectives					Notes
				Std		Wtr Rts		NP	
				Flw	Qty	Flw	Qty	Qty	
LLNL_ALP	LLNL Treatment Effluent Discharge to ALP	Inflow/ Outflow	Meter	D	D				EC only, supplied by LLNL & annually by Zone 7 lab
LLNL_SECO	LLNL Treatment Effluent Discharge to SECO	Inflow/ Outflow	Meter	D	D				EC only, supplied by LLNL & annually by Zone 7 lab
ALPL	Arroyo Las Positas at Livermore	Measurement	Recorder	R	A				Std Analysis, Also EC Recorder data
ALPL_ELCH	Arroyo Las Positas at El Charro	Measurement	Recorder	R	A				Std Analysis
Altamont Creek—Line R									
SBA_ALTC	SBA Turnout to Altamont Creek	Inflow/ Outflow	Meter	D					
LIV_DIV_BPT	Livermore Diversion from Brushy Peak Trib	Inflow/ Outflow	Meter	D					
Arroyo Mocho—Line G									
AMNL	Arroyo Mocho near Livermore	Measurement	Recorder	R	A				Std Analysis, Also EC Recorder data
SBA_AM	SBA Turnout to Arroyo Mocho	Inflow/ Outflow	Meter	D					Std Analysis, Also EC Recorder data
AM_WF	Arroyo Mocho at Wente Ford	Measurement	Calculated	D					
WEN_DIV_AM	Wente Diversion from Arroyo Mocho	Inflow/ Outflow	Meter	D					
AMHAG	Arroyo Mocho at Livermore (Hagemann)	Measurement	Meter	R	A				Std Analysis, Also EC Recorder data
MA_CM_AM_E1	Calmat Discharge to AM at Site E1	Inflow/ Outflow	Recorder	D					Quality monitored at source in MA Program
MA_CM_AM_E2	Calmat Discharge to AM at Site E2	Inflow/ Outflow	Meter	D					Quality monitored at source in MA Program

Site	Location	Type	Device	Objectives					Notes
				Std		Wtr Rts		NP	
				Flw	Qty	Flw	Qty	Qty	
MA_CM_AM_E3	Calmat Discharge to AM at Site E3	Inflow/ Outflow	Meter	D					Quality monitored at source in MA Program
MA_CM_AM	Calmat Discharge to Arroyo Mocho	Inflow/ Outflow	Calculated	D					Quality monitored at source in MA Program
MA_CM_AM_EXP	Calmat Discharge to AM—Exported from basin	Inflow/ Outflow	Calculated	D					Quality monitored at source in MA Program
AM_KB	Arroyo Mocho at Kaiser Bridge	Measurement	Calculated	R	A				Std Analysis
SR1_AM	Stoneridge 1 Waste to Arroyo Mocho	Inflow/ Outflow	Recorder	D					
AMP	Arroyo Mocho near Pleasanton	Measurement	Meter	R	A				Std Analysis; also EC Recorder
MOC1_AM	Mocho 1 Waste to Arroyo Mocho	Inflow/ Outflow	Recorder	D					
MOC3_AM	Mocho 3 Waste to Arroyo Mocho	Inflow/ Outflow	Meter	D					
MOC4_AM	Mocho 4 Waste to Arroyo Mocho	Inflow/ Outflow	Meter	D					
HOP6_AM	Hopyard 6 Waste Arroyo Mocho	Inflow/ Outflow	Meter	D					
Arroyo Valle—Line E									
AVBLC	Arroyo Valle below Lang Canyon	Measurement	Recorder	R	A				Std Analysis
LDV_FLD_GATE	LDV Flood Gate	Inflow/ Outflow	Meter	D					
LDV_FLD_TTL	LDV Total Flood Release	Inflow/ Outflow	Calculated	D					
SBA_TO2_AV	SBA Turnout 2 to Arroyo Valle	Inflow/ Outflow	Meter	D					
AVNL	Arroyo Valle Near Livermore	Measurement	Recorder	R	A	R	Q		Std Analysis
SBA_TO1_AV	SBA Turnout 1 to Arroyo Valle	Inflow/ Outflow	Meter	D					
SBA_AV_TTL	SBA Turnouts to Arroyo Valle Total	Inflow/ Outflow	Calculated	D					
AV_ASGP	Arroyo Valle above	Measurement	Calculated	D					

Site	Location	Type	Device	Objectives					Notes
				Std		Wtr Rts		NP	
				Flw	Qlty	Flw	Qlty	Qlty	
	Sycamore Grove Park								
AV_AVBRDG	Arroyo Valle above Vallecitos Bridge	Measurement	None	D					
AV_VBRDB	Arroyo Valle at Vallecitos Bridge	Measurement	Staff	D					
AV_ASTRIB	Arroyo Valle above South Trib	Measurement	None	D					
AV_ISABEL	Arroyo Valle at Isabel	Measurement	Staff	D					
AV_PONDS	Arroyo Valle at Ponds	Measurement	Staff	D					
MA_LS_SC	Lonestar Discharge to Shadow Cliffs	Inflow/ Outflow	Meter	D					
MA_LS_AV	Lonestar Discharge to Arroyo Valle	Inflow/ Outflow	Meter	D					
AV_DIV_SC	Arroyo Valle Diversion to Shadow Cliffs	Inflow/ Outflow	Meter	D					
MA_LS_AV_EXP	Lonestar Discharge to AV—exported from basin	Inflow/ Outflow	Calculated	D					
ADVP	Arroyo Valle at Pleasanton	Measurement	Recorder	R	A	R	Q		Std Analysis, Also EC Recorder data
South Tributary									
STRIB_ADVWTP	South Trib above DVWTP	Measurement	None					A	Dry in 2004
DVWTP_DISCH	DVWTP Discharge to South Trib	Inflow/ Outflow	Meter	D					Sample in February 2004
STRIB_KB	South Trib at Kalthoff Bridge	Measurement	Staff					A	Sample in February 2004
STRIP_AAV	South Trib above Arroyo Valle	Measurement	None	W					Sample in February 2004
Number of Sites in 2004 Programs: 51				Totals:	47	12	2	2	4
Abbreviations: Objectives: Std = Standard; Wtr Rts = Water Rights; NP = NPDES; Flw = Flow; Qlty = Quality Frequencies: A =Annual; Q = Quarterly; M = Monthly; W = Weekly; D = Daily; R = Recorder (15 minutes). Std Analysis = EC, T, pH, Minerals; EC = Electrical Conductivity, T = Temperature. Updated Friday, May 20, 2005.									

Zone 7's Surface Water Monitoring Program includes the monitoring of surface water stations for the following reasons and/or regulatory objectives:

- **Watershed Monitoring (Std in Table 4-5)**—to calculate the quantity and quality of surface water (natural and artificial) recharging into the main

basin, characterize seasonal water quality variations, and develop a historical database of base-flow water quality.

- **Water Rights (Wtr Rts in Table 4-5)**—The conditions of Zone 7’s water rights permit require that Zone 7 conduct a groundwater investigation that includes quarterly sampling and continuous flow recording at two surface water recorder stations.
- **NPDES (NP in Table 4-5)**—The conditions of Zone 7’s Water Treatment Facilities General NPDES permit and NPDES Storm Water (Non-Point Discharge) permit require that Zone 7 sample above and below existing treatment plant discharges to the streams and at other relevant points in the watershed.

Ten sites in the program are equipped with recorders that produce a continuous gage-height record (15-minute intervals), seven of which are operated by Zone 7, and the other three are owned and operated by the USGS. The other sites in the program (staff gages, meters, calculated, or other) have daily values for flow (except for STRIB_AAV which has weekly values).

Currently three recorder sites record 15-minute data sets for electrical conductivity (EC). Because of the recent relocation and maintenance issues, four other recorder stations are currently not configured to record EC, but are expected to be updated soon. The three USGS recorder stations are not configured for recording EC because they are in areas that have limited impacts on basin water quality.

Grab samples are taken monthly from all stations and field tested for EC. All ten recorder sites and four NPDES sites in the program are sampled annually and submitted to the laboratory for analysis. Zone 7 also collects an annual grab sample from two Lawrence Livermore National Laboratory (LLNL) discharge sites for laboratory analysis in addition to reviewing weekly EC data and monthly laboratory data reported by LLNL. Most of the LLNL water used on site for irrigation and is of adequate quality to be used off-site for irrigation of parks, landscaping or vineyards, if desired by the community.

As necessary, Zone 7 also performs synoptic studies designed to monitor the exchange of ground and surface waters, the rates of recharge along stream reaches, and the areas of basin or sub-basin groundwater outflow. These studies consist of a series of measurements made during periods of stable flow. The variations in flow from station to station generally represent steady-state groundwater recharge or discharge (rising water). Flow and water quality data are collected as part of each synoptic study.

4.5.3.3 Reporting

As part of the surface water program, Zone 7 compiles available current and historical data. The following reports are generated to present the data:

- Daily Stream Flow Report (internal use—primarily to manage the artificial stream recharge program),
- Weekly Surface Water Report (internal use only),
- Monthly Surface Water Report (includes a summary of stream flows from recorder stations, averaged and recorded daily, and a tabulation of stream conductivity),
- Surface Water Annual Monitoring Report, and
- Program Design Report for Surface Water Program.

The results of this program are used for the supply and demand inventory, recharge calculations, salt management, and groundwater modeling.

4.5.4 Land Surface Elevation and Inelastic Subsidence Monitoring

4.5.4.1 Background/Introduction

In accordance with DWR requirements for GMPs, Zone 7 established a formal Land Surface Elevation Monitoring Program in November 2002. The program, which focuses on identifying possible changes in land surface elevations resulting from groundwater pumping, is designed to document long-term land surface elevation changes and determine whether these changes are elastic and/or inelastic.¹

4.5.4.2 Program Description

The program includes:

- compiling historical records of benchmark elevations;
- compiling any records of infrastructure failures that could possibly be associated with subsidence. This has included monitoring for surficial signs of possible subsidence (e.g., hardscape cracking, well casing failures, damaged pipelines); and
- semiannual surveying of a network of about 80 benchmarks and other survey points.

The majority of the points consist of a main circuit (A1) that:

- begins on Livermore Formation on the west side of the valley floor (Site A1-1.0),

¹ Zone 7 2004e.

- transverses the main basin across the Bernal and West Amador sub-basins to the northern boundary of the Main Basin (to Site A1-9.0), and then
- traverses to the southern boundary of the Main Basin on Livermore Formation (to Site A1-17.0).

Several smaller circuits (B1 to B7) branch off of this main circuit. Table 4-5, above, lists the sites in the programs. Figure 4-4 shows the locations of the circuit benchmarks and active municipal pumping wells in the area.



For groundwater elevation reference points, Zone 7 also surveys small circuits in and around Zone 7 pumping wells. These small circuits, described in Table 4-6, branch off of the circuits discussed above. For map clarity, these points are not shown on Figure 4-4.

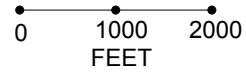
Table 4-6. Land Surface Elevation Monitoring Survey Points and Descriptions

Sites Monitored by Keir and Wright				Additional Well Sites Monitored by Zone 7			
Site ID	Well ID	Survey Points	Description	Site ID	Well ID	Survey Points	Description
A1-1.0*		G972	Brass disk located in sidewalk	AW1-P	3S/1E 8H 2	Army Well 1, Pedestal	Army Well 1 well pedestal
A1-2.0		Foot-La-Pos	Chisel mark on bridge footing	AW1-RP	3S/1E 8H 2	Army Well 1, RP	Army Well 1 reference point
A1-3.0		C972	Brass disk mounted on bridge platform	AW2-P	3S/1E 8H 3	Army Well 2, Pedestal	Army Well 2 well pedestal
A1-4.0		Mocho-Chabot	Brass disk located on access road	AW3-P	3S/1E 8H 4	Army Well 3, Pedestal	Army Well 3 well pedestal
A1-5.0		Mocho-Tass-W	Brass disk located on access road	H6-C	3S/1E 18A 6	Hopyard 6, Casing	Hop 6 casing/flange
A1-6.0		Mocho-Tass-E	Brass disk located on access road	H6-D	3S/1E 18A 6	Hopyard 6, Drain	Hop 6 drain
A1-7.0		Mocho_CB	Chisel mark on catch basin	H6-F	3S/1E 18A 6	Hopyard 6, Floor	Hop 6 chisel mark on pumphouse floor
A1-8.0		M1257	Brass disk mounted on bridge platform	H6-P	3S/1E 18A 6	Hopyard 6, Pedestal	Hop 6 well pedestal
A1-9.0*		Tass_Rose	Proposed disk on bridge foundation	H6-RP	3S/1E 18A 6	Hopyard 6, RP	Hop 6 reference point Hop 9 transformer pad
A1-10.0		L1257	Disk	H9-T	3S/1E 17D12	Hopyard 9, Transformer	
A1-11.0		Vine-Pipe	Brass disk in concrete	H9-C	3S/1E 17D12	Hopyard 9, Casing	Hop 9 casing/flange
A1-12.0		Mohr-RR	Spike at Mohr Ave and RR	H9-F	3S/1E 17D12	Hopyard 9, Floor	Hop 9 chisel mark on pumphouse floor
A1-13.0		TBM2		H9-P	3S/1E 17D12	Hopyard 9, Pedestal	Hop 9 well pedestal
A1-14.0		Bush-Valley	Brass disk (?) City benchmark	H9-RP	3S/1E 17D12	Hopyard 9, RP	Hop 9 reference point

Figure 4-4

LEGEND

-  Benchmark Location
 Active Municipal Well



ZONE 7 WATER AGENCY

Benchmark Locations

BY:
GG/TR

DATE:	Mar 1, 2004
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E:\monitor\em\2003wy\
Annual\Fig1EMLocations.wor

Sites Monitored by Keir and Wright				Additional Well Sites Monitored by Zone 7			
Site ID	Well ID	Survey Points	Description	Site ID	Well ID	Survey Points	Description
A1-15.0		D8	Brass disk on bridge foundation	M1-C	3S/1E 9M 2	Mocho 1, Casing	Mocho 1 casing/flange
A1-16.0		V1	Brass disk	M1-P	3S/1E 9M 2	Mocho 1, Pedestal	Mocho 1 well pedestal
A1-17.0*		K2	Brass disk (?) NGVD Benchmark	M1-RP	3S/1E 9M 2	Mocho 1, RP	Mocho 1 reference point
B1-1.0		Mocho-san MP3	Proposed disk on bridge Platform	M1-T	3S/1E 9M 2	Mocho 1, Transformer	Mocho 1 transformer pad
B1-2.0		Mocho-san MP2	Proposed disk on bridge Platform	M3-C	3S/1E 9M 4	Mocho 3, Casing	Mocho 3 casing/flange
B1-3.0		Mocho-san MP1	Proposed disk on bridge Platform	M3-P	3S/1E 9M 4	Mocho 3, Pedestal	Mocho 3 well pedestal
B1-4.0	3S/1E 8H 3	Army Well 2, Floor	Chisel mark on pumphouse floor	M3-RP	3S/1E 9M 4	Mocho 3, RP	Mocho 3 reference point
B1-5.0	3S/1E 8H 18	Mocho 4, Floor	Shiner at entrance door	M3-T	3S/1E 9M 4	Mocho 3, Transformer	Mocho 3 transformer pad
B1-6.0	3S/1E 8H 2	Army Well 1, Floor	Chisel mark on pumphouse floor	M4-C	3S/1E 8H18	Mocho 4, Casing	Mocho 4 casing/flange
B1-7.0		Mocho-Stone MP1	Proposed disk on bridge Platform	M4-P	3S/1E 8H18	Mocho 4, Pedestal	Mocho 4 well pedestal
B1-8.0		Mocho-Stone MP2	Proposed disk on bridge Platform	M4-RP	3S/1E 8H18	Mocho 4, RP	Mocho 4 reference point
B1-9.0		Mocho-Stone MP3	Proposed disk on bridge Platform	M4-T	3S/1E 8H18	Mocho 4, Transformer	Mocho 4 transformer pad
B1-10.0		Mocho-Stone MP4	Proposed disk on bridge Platform	S-D	3S/1E 9B 1	Stoneridge, Drain	Stoneridge drain
B1-11.0	3S/1E 8H 4	Army Well 3, Floor	Chisel mark on pumphouse floor	S-P	3S/1E 9B 1	Stoneridge, Pedestal	Stoneridge well pedestal
B1-12.0	3S/1E 8H 13	Obs. Well, Casing	Chisel mark on casing	S-RP	3S/1E 9B 1	Stoneridge, RP	Stoneridge reference point
B1-13.0	3S/1E 9M 4	Mocho 3, Shiner	Shiner at entrance door	S-C	3S/1E 9B 1	Stoneridge, Casing	Stoneridge casing/flange
B1-14.0	3S/1E 9M 2	Mocho 1, Floor	Chisel mark on pumphouse floor				
B1-16.0	3S/1E 9M 3	Mocho 2, Floor	Chisel mark on entrance door				
B2-1.0		Tass-Las-Pos MP1	Proposed disk on bridge Platform				
B2-2.0		Tass-Las-Pos MP2	Proposed disk on bridge Platform				
B2-3.0		Tass-Las-Pos MP3	Proposed disk on bridge Platform				
B2-4.0		Tass-Las-Pos MP4	Proposed disk on bridge Platform				
B3-1.0		Mocho-Park	Brass disk on concrete vault				
B3-2.0		1H ALA	County Benchmark				
B3-3.0	3S/1E 17D12	Hop 9 BM	Benchmark, rod in access road				

Sites Monitored by Keir and Wright				Additional Well Sites Monitored by Zone 7			
Site ID	Well ID	Survey Points	Description	Site ID	Well ID	Survey Points	Description
B4-1.0		AMP-Ctl S	Brass Disk on Control				
B4-2.0	3S/1E 9B1	Stoneridge, Floor	Chisel mark at entrance door				
B5-1.0		OSRR-BC	New Monument Disk				
B5-2.0		OSRR-Andrew	New Monument Disk				
B5-3.0		OSRR-Café	New Monument Disk				
B6-1.0		5608 Belleza	New Monument Disk				
B6-2.0		FLORA-end	New Monument Disk				
B6-3.0		Belleza-Verd	New Monument Disk				
B7-1.0		Larame-Larame	New Monument Disk				
B7-2.0		Suttr-Larame	New Monument Disk				
B7-3.0		Suttr-Jones	New Monument Disk				
* Probable bedrock sites.							

4.5.4.3 Reporting

Throughout the water year several reports are generated to display, review, and discuss the data that were gathered:

- Land Surface Elevation Semiannual Monitoring Report,
- Land Surface Elevation Monitoring Report—annually, and
- Land Surface Elevation Monitoring Program Design Report—annually.

The results of this monitoring program are used to measure and document any changes in land surface elevation that could possibly be associated with elastic or inelastic subsidence. The oldest benchmark in the program dates back to 1912 and has moved possibly about 3 inches. These records are used to help identify whether there are any negative impacts from groundwater pumping on ground surface elevations.

4.5.5 Mining Area Monitoring

4.5.5.1 Background/Introduction

Mining of sand and gravel in the Livermore-Amador Valley began prior to 1900. As demands continued to grow, and larger areas and volumes of sand and gravel were removed, the need for a regulatory system became apparent. In 1956 the County of Alameda adopted Ordinance 181 N.S. Ordinance 181 N.S. prohibited

pollution or contamination of usable water-bearing strata.² In addition, the early permits, as well as later permits, limited the mining to the uppermost aquifer. More recent permits, beginning in 1965, contained more specific language for protecting water resources and reclamation plans. In 1977, Alameda County adopted a new surface mining ordinance updating the 1956 Quarry Ordinance and incorporated reclamation requirements.³

In 1980 a gravel mining reclamation plan was adopted by Alameda County and local mining companies. The plan called for the completion of a “chain of interconnected ponds which would allow routing of storm waters through the mining area and subsequent recharge in the west.” This plan was designed to mitigate the loss of stream recharge capacity, loss of groundwater basin storage, loss of water through increased evaporation and loss of groundwater transport through the upper aquifer towards the sub-basins on the west side of the basin. When completed in 2030, Zone 7 will own and operate this “Chain of Lakes” for groundwater basin management purposes.

4.5.5.2 Program Description

Since gravel-mining operations have had an appreciable effect on groundwater levels and quality in the main groundwater basin, Zone 7 has incorporated a mining component into the monitoring network. A pit numbering system was developed by Zone 7 staff in 1972 and is still used today to identify active and inactive pit areas.

The current program consists primarily of monthly and semiannual monitoring. Monthly observations include determination of water surface elevations and water quality from twelve major pits. In addition, monthly observations included recording any change in mining operations. Water surface elevations and EC readings are done for each of the monthly pits. A TDS value is estimated based on the EC readings. Twice a year, in the spring and fall, all monthly monitored ponds are sampled for a complete mineralogical analysis at the Zone 7 laboratory. Monthly monitoring also includes a review of stream discharge reports received from the mining companies, which includes a compilation of daily and monthly stream discharge meters and data. The semiannual monitoring consists of a more extensive inventory of all significant pits and ponds in the mining areas. Semiannual monitoring includes surface water elevation measurements, EC, and determination of evapotranspiration rates. In addition, a water quality sample for laboratory analysis is collected from each pond on an annual basis. Figure 4-5 shows the location of the gravel mining pits.

² Alameda County 1981.

³ Alameda County 1981.

4.5.5.3 Reporting

Throughout the water year several reports are generated to display, review, and discuss the data that were gathered:

- Gravel Mining Groundwater Export and Evaporation Report—monthly,
- Mining Area monthly and semiannual reports (internal), and
- Mining Area Annual Report.

The results of this program are used for the supply and demand inventory, recharge calculations, salt management, and groundwater modeling.

4.5.6 Land Use Monitoring

4.5.6.1 Background/Introduction

Collection of land use data is essential in understanding changes in land and water use over time that may affect infiltration and water quality in the groundwater basin. To properly assess water supply and water quality conditions and trends in the groundwater basin, accurate records of land and water use changes are needed. Zone 7 identifies and quantifies different types of land uses with irrigation significant enough to contribute groundwater recharge and affect the salt loading of the Main Basin. The program also identifies the type of water (potable, groundwater, or recycled) for use in the computation of salt loading to the Main Basin.

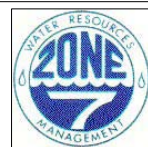
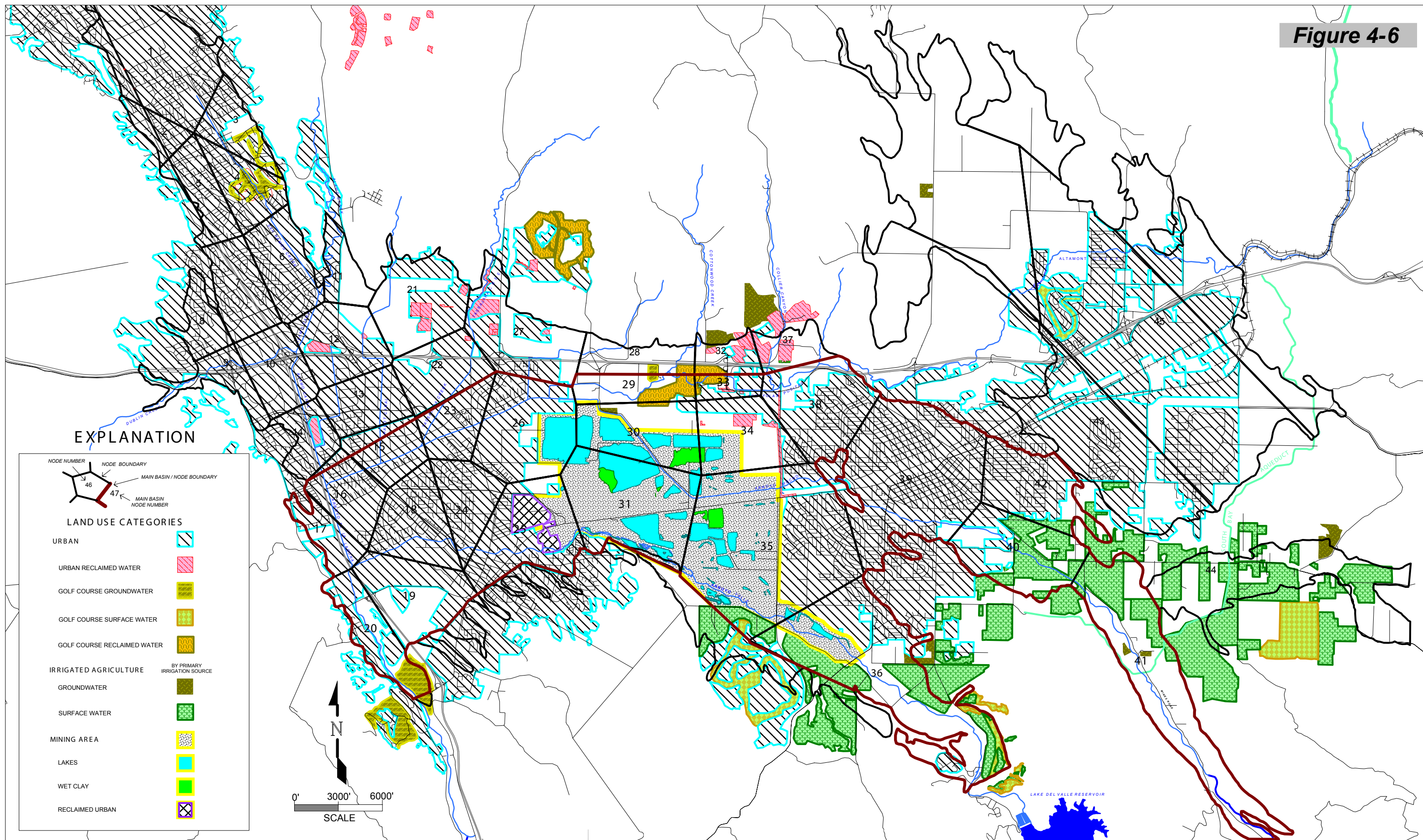
4.5.6.2 Program Description

As part of Zone 7's long-term monitoring program, land use in the Livermore-Amador Valley is monitored. Zone 7's Land Use Monitoring Program includes the identification of the following different land use type (see Figure 4-6):

- **Urban** land use includes residential and commercial areas, which typically are irrigated. Small vacant lots, non-irrigated fields and other undeveloped areas are included as urban land if they are smaller than about 20 acres and are located in urban areas.⁴ Each urban classification is composed of several subcategories. For example, Urban Reclaimed Water lands are urban areas subject to reclaimed wastewater irrigation. Such urban areas include landscaped regions surrounding the valleys, two wastewater treatment facilities, the Livermore Airport, the Dublin Sports Grounds, parts of east Dublin and the area north of Interstate 580 along Canyons Parkway, including Las Positas College. Golf courses are included in the urban category and are divided into three subcategories: golf course groundwater, golf course surface water, and golf course reclaimed water.

⁴ Zone 7 2003, 2004f.

Figure 4-6



ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	TODD WENDLER
DESIGNED	TODD WENDLER
CHECKED	
APPROVED	

**WATER RESOURCES
LIVERMORE VALLEY LANDUSE
2004 WATER YEAR**

SCALE	1" = 6000'
DATE	29 November 2004
FILE NO.	B-140 LU_04.WOR

- **Irrigated/Agriculture** land use consists of irrigated farmland such as vineyards, field crops, vegetable crops and pastures. Excluded from this category is agricultural land that is dry-farmed or minimally irrigated during the growing season. Irrigated areas, also shown in Figure 4-6, have been subdivided by primary water sources as groundwater or surface water. The vineyard areas are irrigated primarily with surface water obtained from the SBA. Some groundwater can be used in the vineyards to supplement the SBA water, but because the amount used is proportionally small, these areas are listed as surface water irrigated. Beginning in 2001, Zone 7 maps included agricultural lands irrigated with recycled water.
- **Gravel Mining Area** land use includes all lands that have been mined or are scheduled to be mined. Mining area “ponds” include all areas of ponded water or wet silt. The wet silt areas are counted as ponded area because evaporative losses from wet silt are similar to evaporation that occurs in open ponds. Mining area “reclaimed” includes all lands mined and refilled or partially refilled with clay. Mining area “urban” includes lands within the mining area that have been reclaimed and developed into industrial parks or similar urban uses. The “irrigated agriculture” category is located outside of the mining area. Mining area “other” includes excavations, earthworks, and undisturbed lands within the mining area that do not belong in any other mining area classification.

Land use data are derived from aerial photography (annual), interviews with landowners, and field observations. Land use changes are monitored and evaluated in a monthly site review report. This report tracks all new land use changes and is used to coordinate Zone 7 concerns to the land use planning agencies.

4.5.6.3 Reporting

The Livermore Valley Land Use Report is generated annually to display, review, and discuss changes in land use and water use that may impact the regional water supply or the groundwater basin. In addition, a site review report of all potential land use changes that may impact the groundwater basin is compiled and reviewed each month. The results of this program are used for the recharge calculations (of rainfall recharge and applied water recharge).

4.5.7 Groundwater Production

4.5.7.1 Background/Introduction

The extraction of groundwater for municipal, industrial, domestic and agricultural use represents more than 80% of the groundwater flow through the basin. Maintaining accurate records of the quantity and location of all groundwater extractions is critical for basin evaluations and modeling. This program compiles daily, monthly, and annual records of groundwater extraction

from all significant wells within the groundwater basin. More specifically, this program includes groundwater levels, monthly production amounts, and water quality analyses for all municipal supply wells to determine the amount and quality of water that is being extracted from the groundwater basin for municipal and/or agricultural use.

Accurate records have been kept on monthly production quantities since 1974. The records are vital to accounting of groundwater use and to the proper allocation of waters recharged artificially and subsequently pumped by Zone 7 versus waters naturally recharged into the groundwater basin and subsequently pumped by retailers or others.

Historical records prior to 1974 are incomplete and use prior to the 1960s must be estimated based on land use mapping and limited pumping records.

4.5.7.2 Program Description

Zone 7 collects and compiles monthly records for all large pumping wells within the Main Basin. Zone 7 meters all Zone 7 pumping and requires metered pumping records from all retailer wells. Records of other pumping wells are obtained from well owners when available. Pumping records from smaller wells or wells without meters are calculated from power records or from land use data. Zone 7 obtains these records as part of the land use mapping program and the groundwater level-monitoring program.

4.5.7.3 Reporting

Zone 7 tracks and reviews Zone 7 pumping each day and reports the amount in a daily production report. The Monthly Municipal Water Supply report compiles reviews of municipal pumping from all wells valley-wide. Any discrepancies or lapses in the data stream are resolved to prevent the loss of well pumping data. The records from local retailers are compared to contractual pumping limits (formerly referred to as Independent Quotas) and, in the event of overpumping, the retailers are billed for the excess water.

4.5.8 Wastewater and Recycled Water Monitoring

4.5.8.1 Background/Introduction

Wastewater disposal from domestic and commercial sites can have a significant impact on water resources and a groundwater basin. While wastewater disposal can contribute a significant quantity of water to recharging the basin, it can also be a potential source of contamination, primarily from salts, nitrates and chlorides.

Zone 7 completed numerous studies of wastewater disposal and water quality management including an early study entitled, “Water Quality Management Plan for the Alameda Creek Watershed above Niles,” in September 1972. Subsequent joint studies by USGS and Zone 7, along with actions by the California Regional Water Quality Control Board—San Francisco Bay Region and the Zone 7 Board resulted in the creation of the Livermore Amador Valley Water Management Agency (LAVWMA) which eventually constructed an export pipe. Since 1979, the LAVWMA export pipe has exported most urban wastewater out of the watershed and into the San Francisco Bay. The remainder of the locally-sewered water receives tertiary treatment and is currently distributed as recycled water for landscape irrigation (for additional discussion of wastewater management, see Section 5.1.4.4).

Figure 4-7 shows the land use and wastewater disposal changes over the past 35 years. Note that prior to the LAVWMA pipeline construction, all urban wastewater was disposed in the valley with significant amounts of wastewater either flowing out of the basin via the local arroyos or percolating into the groundwater basin. The Wastewater Management policies established by Zone 7 in the 1970s successfully supported regional sewerage for the majority of developed lands overlying the entire groundwater basin and for essentially all of the lands overlying the Main Basin. Thus wastewater from the majority of sewerage areas is exported out of the basin via the LAVWMA export pipeline.

As discussed in Sections 3.5 and 5.1.4.4, there is a groundwater contamination plume containing high levels of nitrates existing in the eastern portion of the Main Basin. There have been several evaluations suggesting a variety of sources for these nitrates. There remain a few localized unsewered areas with a high density of residential septic tanks (i.e., Buena Vista Avenue near the upper end of this plume, along with both the Happy Valley and Sunol areas which are separate from the above-described plume) that may or may not be contributing to nitrate loading within the basin. Since these areas are relatively rural and are typified by various livestock (both currently and historically), nitrate remains a concern.

In some areas, large tracts of land have been dedicated as permanent open space, which is unlikely to generate much urban wastewater on site (although application of recycled water for landscape or agricultural irrigation is potentially possible, as are on-site septic tanks, fertilizer applications, winery wastes used to augment irrigation water, etc.). These lands include large regional parks and areas within agricultural land trusts. The other large area within the Main Basin that is excluded from significant in-valley wastewater disposal is the Mining Area, which will either be developed and sewerage (with wastewater exported from watershed) or be left as permanent open space.

4.5.8.2 Program Description

Zone 7 currently tracks wastewater disposal on a monthly basis. NPDES permits for the City of Livermore and the DSRSD wastewater treatment plants are reviewed monthly. Flow and quality data are evaluated for impacts to the groundwater basin. In the future the wastewater flows will be tracked on a daily

basis so that the Concentrate from the Groundwater Demineralization projects can be coordinated with wastewater discharges into the LAVWMA pipeline. Recycled water use is also tracked monthly for water use, flow and location of use. Additional description of Zone 7's wastewater management program is contained in Section 5.1.4.4.

4.5.8.3 Reporting

The flow and quality data is compiled in a monthly Wastewater and Recycled Water Report for internal use by Zone 7 staff and the location of recycled water applications are mapped in the Land Use Annual Report. The data are used for hydrologic inventory calculations, salt balance calculations, and groundwater modeling.

4.6 Basin Evaluation Programs

4.6.1 Introduction

The data and results of Zone 7's monitoring programs are used to evaluate the conditions of the groundwater basin. This section of the GMP describes Zone 7's programs designed to evaluate the conditions of the basin using data collected from the monitoring described above. Following data collection and reporting for the monitoring programs, Zone 7 performs detailed evaluations and analyses that include data from more than one monitoring program. These data are described below and include:

- recharge calculations,
- hydrologic inventory,
- groundwater basin storage,
- salt balance calculations, and
- municipal water supply.

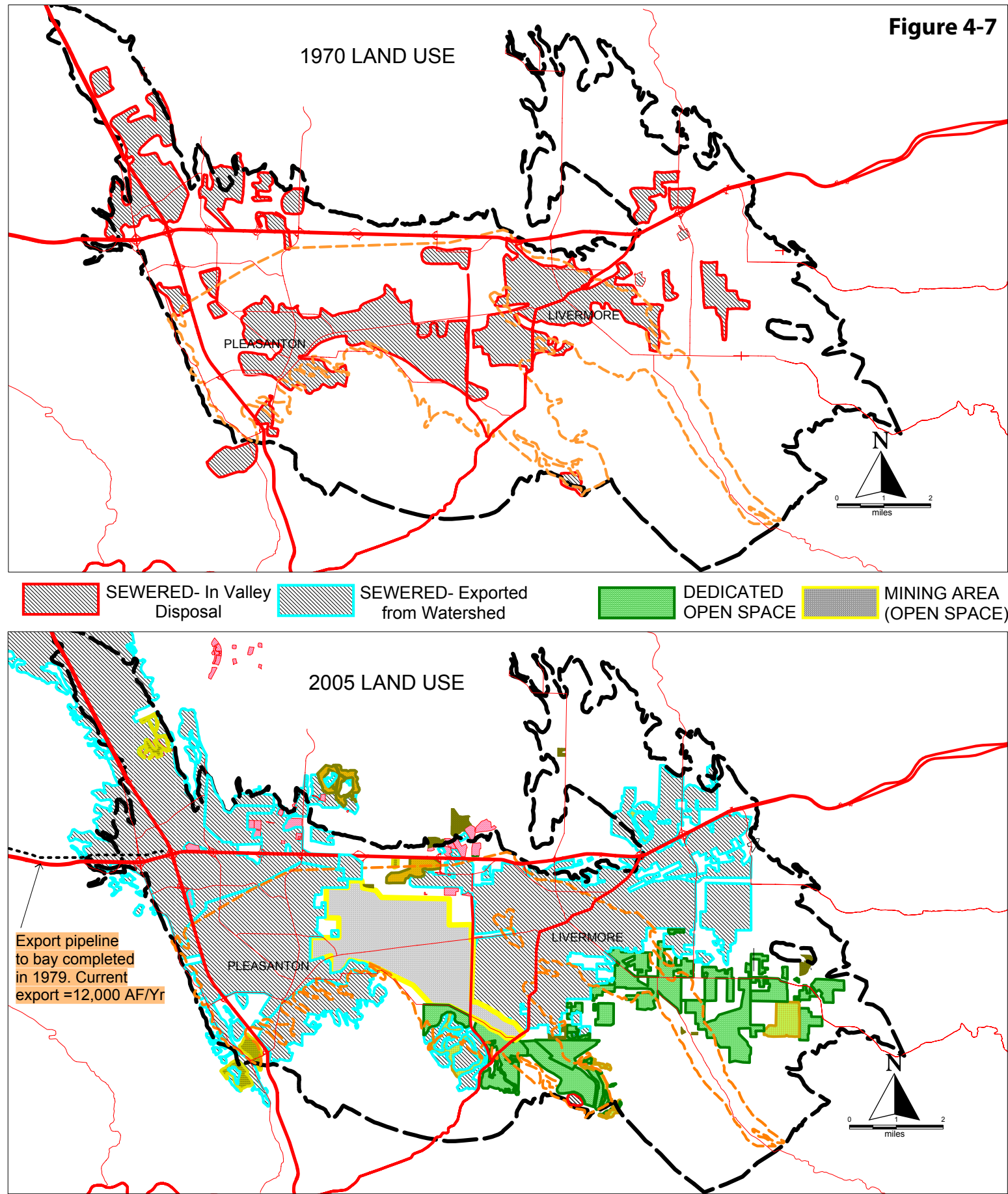
4.6.2 Recharge Calculations

Groundwater recharge occurs from rainfall, applied water, and streams, all of which are calculated by Zone 7. In the future, Zone 7 also plans to use mining area lakes as recharge ponds.

Zone 7 has developed a recharge calculation model that calculates both rainfall and applied water recharge rates for all locations in the groundwater basin. The recharge model, which includes results from the climatological and land use monitoring programs, includes parameters for soil type and hydrologic conditions

LAND USE & WASTEWATER DISPOSAL CHANGES OVER 35 YEARS

Figure 4-7



throughout the valley. For modeling the groundwater basin, rainfall and applied recharge are combined as a real recharge.

Groundwater recharge from streams includes the following components:

- natural recharge—rain runoff into the streams, including both urban runoff from rainfall and upper watershed runoff that recharge into the streambeds;
- artificial recharge—SBA or Lake del Valle water that is released into the streams; and
- gravel-mining recharge/discharge—recharge from gravel mining pit discharges or discharges into the streams.

Stream recharge is calculated from daily streamflow and stream discharge records. The three primary recharge streams have upstream and downstream gages, and the recharge typically is calculated as the difference between upstream inflows and downstream outflows.

4.6.3 Hydrologic Inventory and Water Balance

Zone 7 compiles a detailed hydrologic inventory or water balance of monthly and annual supply and demand components for the Main Basin. The hydrologic inventory represents the water balance between groundwater supply and groundwater demand. The inflow and outflow components of the Main Basin budget are presented in Table 4-7. Monthly inventory summaries are compiled each quarter and reported in the quarterly water supply report that is presented to the Zone 7 Board each quarter. The hydrologic inventory is the easiest way to keep track of changes in groundwater storage. Experience gained through the analysis of the hydrologic inventory allows Zone 7 staff to predict and model long-term basin response to changing hydrologic conditions.

Table 4-7. Annual Supply and Demand

	2003 Water Year (acre-feet)	Normal Water Year (acre-feet)
Inflows		
Natural Stream Recharge	4,629	4,766
Artificial Stream Recharge	9,588	11,379
Rainfall Recharge	2,041	3,910
Applied Water Recharge	949	1,719
Subsurface Inflow	720	756
Inflow Total	17,926	22,530
Outflows		
Municipal Pumping	13,471	13,456
Agricultural Pumping	118	1,066
Mining Use	2,233	2,236
Subsurface Outflow	0	405
Outflow Total	15,822	17,163
Net Recharge (Inflow – Outflow)	2,104	5,367

4.6.4 Groundwater Basin Storage

The amount of water in storage is a critical component of water supply management and drought planning. Zone 7 computes groundwater storage using two methods. The inventory method uses the hydrologic inventory to calculate storage changes. The groundwater level method uses groundwater level data and geologic information on aquifer properties to compute storage. Zone 7 has been using both methods for more than 20 years, and they are in close correlation. Each year Zone 7 completes a storage report that reviews the storage calculation based on the inventory method and the groundwater level measurement. Zone 7's experience with these methods allows staff to report with confidence the amount of water within the basin. Knowledge of this information allows Zone 7 staff to plan for extracting a known volume of water without risking lowering the basin below historical lows.

4.6.5 Salt Balance

Saline waters can slowly degrade the quality of groundwater (represented by a rise in basin salinity and/or hardness) and ultimately render part or all of a groundwater basin unusable. In the semi-arid Livermore Valley, multiple sources can contribute to increased salinity in groundwater: use and reuse of the water supply, lateral or upward migration of saline water, downward seepage of industrial or agricultural water, downward seepage of mineralized surface water from streams or lakes, interaquifer migrations of saline water and especially the

evapotranspiration of irrigation water (some of which is relatively high TDS recycled water). The primary purpose of the salt balance evaluation is to investigate the change in the amount of salt in the basin and calculate the basinwide change in water quality.

The Livermore groundwater basin has been experiencing slowly degrading water quality each decade, as evidenced by increasing TDS levels. Preventing the buildup of salts (calcium, magnesium, sodium, chloride, and other minerals) is a key Zone 7 water quality objective. Zone 7 calculates a salt balance to determine whether it is meeting long-term water quality objectives of non-degradation. Under full implementation of the Salt Management Plan (SMP), Zone 7 will increase recharge, increase pumping and bring the salt balance into a non-degradation range.

A salt balance is a calculation of the amount of salts and minerals entering or leaving a groundwater basin. If the balance is positive, the regional water quality will degrade. If the balance is negative, then basin quality will improve. However, for decades, the Groundwater Basin Salt Balance has been positive, confirming the reason basin water quality has continued to decline. Multiple sources can contribute to increased salinity in groundwater. In the semiarid Livermore Valley, the evapotranspiration of irrigation water, especially higher-TDS recycled water, has been the greatest long-term concern from a salt-management perspective.

Currently, the salt balance calculations are based on results from:

1. 45 monitoring wells to track groundwater levels and quality.
2. Six surface water recorder stations to track streamwater flow and quality in three major waterways in the watershed (Arroyo Valle, Arroyo Mocho and Arroyo Las Positas).

Additional wells and surface water recorder stations are under consideration to improve Zone 7's understanding of salt migration from fringe basins and concentration in the Main Basin.

All wells and surface waters used for the evaluation are sampled and analyzed annually for major ions (e.g., Ca, Mg, Na, K, HCO_3 , SO_4 , Cl, NO_3 , SiO_2), boron, manganese, selenium, chromium, arsenic, EC, pH, TDS, alkalinity, and hardness. As surface water monitoring stations are upgraded with automated water quality measuring instruments, EC, temperature, and pH will be recorded on a nearly continuous basis.⁵

Sources of salt loading to the main basin for the 1998 water year are shown in Table 4-8. The table shows that urban irrigation represents a significant portion of the potentially "controllable" portion of the total salt loading to the basin. There is a limit to which the other sources can be controlled, with the possible exception of shallow groundwater pumping that might reduce high TDS subsurface inflow and recharge on Las Positas.

⁵ Zone 7 2004a.

Table 4-8. Main Basin Relative Salt Loading Sources, 1998 Water Year Controllable Portion of the Total Salt

Sources	Relative Salt Load on the Basin
Urban Irrigation	33%
Natural Recharge on Arroyo Mocho	18%
Subsurface Inflow	13%
Natural Recharge on Arroyo Las Positas	14%
Natural Recharge on Arroyo Valley	13%
Agricultural Irrigation	3%
Artificial Recharge	6%

Reports summarizing results of the salt balance evaluation are planned to be generated initially on a quarterly and annual basis. The data collected as part of the salt balance evaluation will be used to identify changes in groundwater quality throughout the watershed, to refine salt loading estimates, and to provide input to the water resource allocation and groundwater models.

Given that the salt balance evaluation program was established in part to identify and fill existing data gaps and to provide a venue to evaluate the long-term effectiveness of the SMP, an annual critique and refinement of the monitoring and data collection effort is anticipated.

Data collected as part of this evaluation will be used to critically evaluate the usefulness of the data collected relative to making salt management control measure decisions. The groundwater model and this monitoring program will be used in a complementary fashion, where monitoring program results are used as input to the model and the monitoring program subsequently uses the output from the model to help determine additional (or reduced) data needs. This approach will help achieve long-term SMP goals without consuming excessive resources that could otherwise be used directly to implement salt management measures.

4.7 Basin Management

4.7.1 Introduction

A groundwater basin is a large natural complex reservoir. Zone 7 regulates more than half of the inflow and outflow from the basin and strives to make the basin function indefinitely to provide a sustainable supply of high quality water to the residents of the Tri Valley.

The basin needs to be managed as a system in order to be operated in an optimal way but the groundwater basin is just a part of a larger complex system that includes the SWP, local watershed runoff, Semitropic storage and treatment

plants. A community of about 190,000 people depend upon optimal use and proper management of the groundwater basin.

Zone 7 uses the information and knowledge gained from monitoring and from conducting the basin evaluation programs to create several models. These models are used to evaluate different basin management scenarios and to test out strategies. Zone 7 then creates a basin management operations plan based on the results of two types of modeling: water operations modeling and groundwater modeling. The modeling uses water supply forecasts from:

- supply and demand modeling,
- groundwater modeling,
- water supply forecasts,
- data from basin evaluation programs,
- knowledge gained by decades of studying the basin, and
- forecasts of potential water supply and demand conditions.

The basin management operations plan is a part of water supply planning and is included in the Annual Water Operations Plan.

4.7.2 Key Wells

Zone 7 has identified key index wells in each significant water-producing region of the Main Basin as general indicators of groundwater levels in the Main Basin. The data from these wells are evaluated quarterly using monthly water level data. The results from this evaluation are assembled onto easy-to-read graphs that can be displayed to the general public (see Figure 4-8).

4.7.2.1 Groundwater Storage

Zone 7 actively monitors groundwater storage in the basin to ensure that future demands are met during dry years. Zone 7 keeps groundwater storage above the main basin historical low, preserving all groundwater underneath the historical low for emergency use. Zone 7 is able to keep the storage above the historical low by importing surface water. Groundwater storage calculations help Zone 7 determine the amount of existing groundwater availability, and future availability, thus providing vital information about the hydrologic inventory of the basin.

4.7.3 Supply and Demand Simulation Modeling

Zone 7's supply and demand simulation model, Z7sim can model the entire Zone 7 system over an 80-year hydrologic period to evaluate long-term strategies or

any deficiencies in resources that would limit providing a reliable supply of water.

The Zone 7 simulation model has a groundwater basin component that calculates the recharge and extraction and change of storage for the Main Basin. Calibrations are ongoing and involve matching model projections to actual groundwater recharge, storage change and groundwater levels.

Through groundwater elevation/storage monitoring and retailer demands, Zone 7 is able to predict the supply of the groundwater basin in relation to the current and future demand.

Zone 7 compiles a detailed hydrologic inventory of annual supply and demand components for the Main Basin and computes the end-of-year storage. The hydrologic inventory represents the water balance between groundwater supply and groundwater demand.

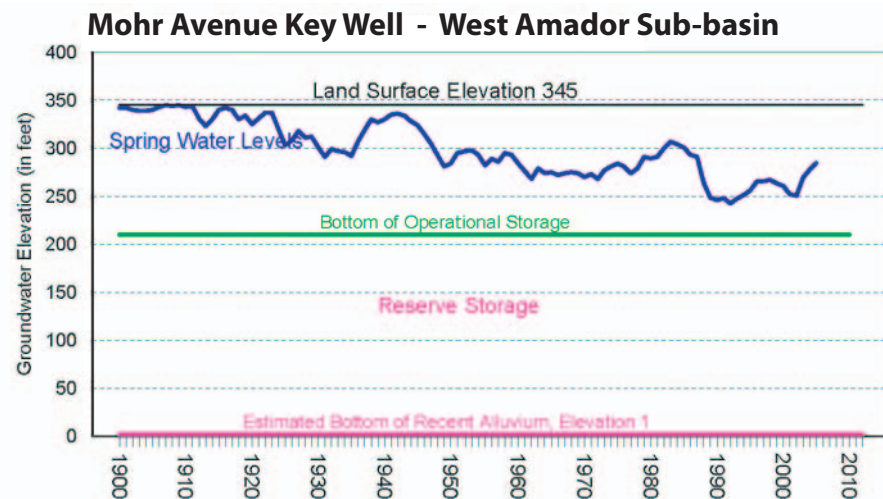
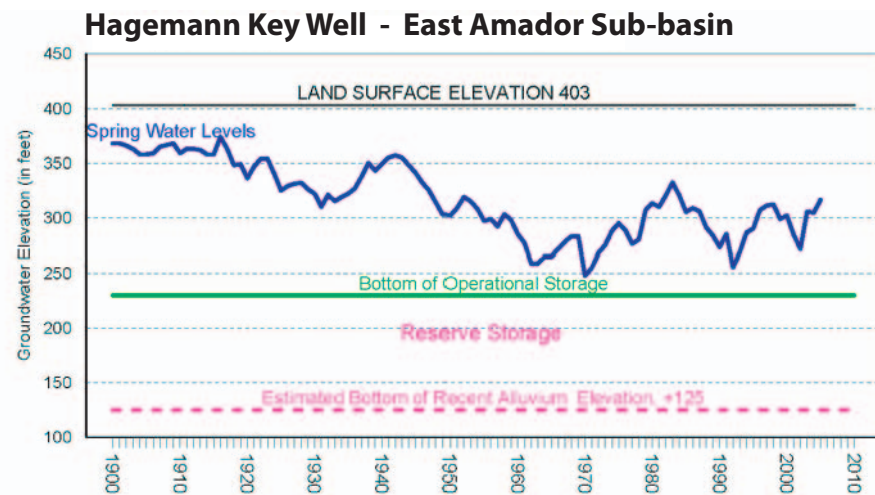
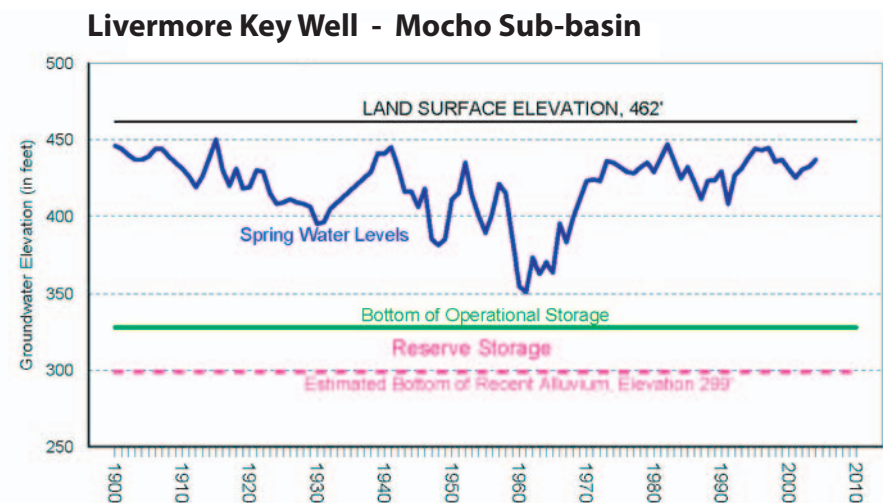
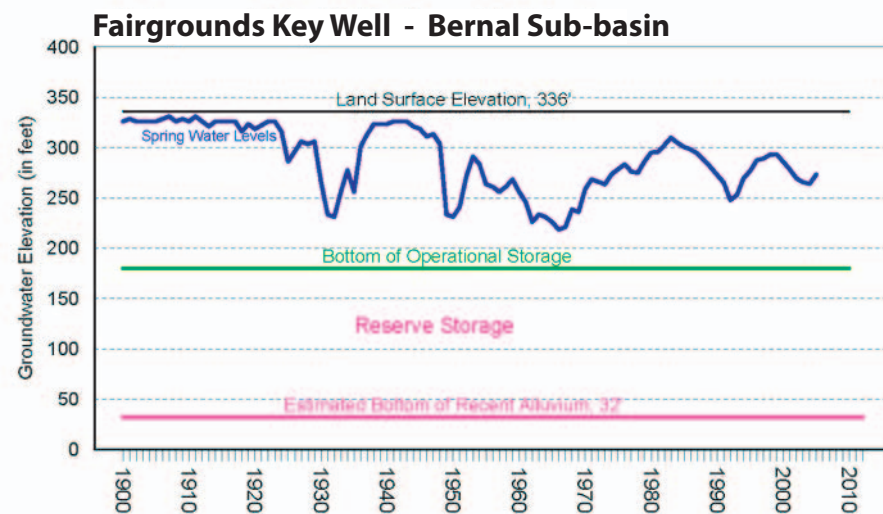
4.7.4 Groundwater Modeling

A groundwater model is a device that represents an approximation of a groundwater basin. Physical models such as laboratory sand tanks simulate groundwater flow directly. A mathematical groundwater model simulates groundwater flow indirectly by means of equations to represent the physical processes that occur in the groundwater basin. A mathematical model can be used analytically or numerically. As analytical solutions are not suitable because of complexities in the groundwater flow modeling, numerical groundwater modeling is more often used for groundwater basin modeling.

Groundwater models are useful for predicting the consequences of a proposed groundwater basin management action. Groundwater models can also be used to learn about the controlling parameters in a site-specific setting such as establishing locations and characteristics of aquifer boundaries.

The original Main Basin groundwater model was developed by Zone 7 and DWR in the 1970s and is documented in DWR Bulletin 118-2. Davies (a Stanford graduate student) developed a groundwater model of the Amador sub-basin in 1981. Danskin (another Stanford graduate student) extended this model into the Bernal sub-basin in December 1985 and calibrated the model for average fluxes for the period 1977–1981. Although these models and the associated documentation provided some useful technical information, Zone 7 did not use them for basin management studies.

In 1996, Zone 7 retained consultant CH2M Hill to assist Zone 7 Staff with the development of a groundwater flow and solute (salt) transport model for the main groundwater basin. The model was designed to be usable by Zone 7 Staff or evaluating alternative SMP strategies and future Main Basin management options. The model was originally developed using Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. package and M+3D for



solute transport. In the late 1990s, the model was converted to Groundwater Vistas using MODFLOW-SURFACT for simulate groundwater flow and MT3D to simulate solute transport.

The model is currently being updated and recalibrated to include recent data sets. The original model was calibrated using data from 1974 to 1994; the updated includes data sets through 2004.